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TITLE: ENDOSCOPE WITH ALTERABLE VIEWING ANGLE

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ENDOSCOPE WITH ALTERABLE VIEWING ANGLE

BACKGROUND

Optical endoscopes are known as devices that may be inserted into a body cavity in order to view an image of an inside of the body cavity. Typical optical endoscopes have a viewing lens at their terminus, which enables viewing areas that are generally in front of the endoscope's end portion.

SUMMARY

The present system defines an endoscope which includes advantageous features. The endoscope includes a mirror which allows viewing from a specified direction that is not necessarily parallel with an axis of the endoscope. In one embodiment, that direction can be varied in specified ways.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects will now be described in accordance with the drawings, in which:

Figures 1A and 1B show a fiber-optic endoscope system of a first embodiment, with Figure 1A showing a fixed mirror embodiment, and Figure 1B showing a movable mirror embodiment;

Figure 2 shows an alternative embodiment which enables viewing dual directions at the same time through an endoscope;

Figure 3 shows an embodiment including a surgical tool associated with the viewing tube;

Figure 4 shows an embodiment in which the endoscope sheath conducts the illumination light;

Figure 5 shows an embodiment with a viewing tube that is shortened relative to other embodiments;

Figure 6 shows an embodiment with a camera located on the insertable portion of the scope; and

Figure 7 shows an embodiment with a movable mirror.

DETAILED DESCRIPTION

Figure 1A shows an embodiment of the endoscope. The endoscope 10 generally includes optical fiber 12 which can be a coherent bundle of optical fibers, or an optical viewing tube or any other type of optical waveguide. An outer sheath 14 surrounds the optical fiber element 12. A space 13 is defined between the outer surface of the fiber 12, and the inner surfaces of the sheath 14. Standoff 48 may be provided between the outer surface of the fiber 12, and the inner surface 46 of the sheath. The standoffs may hold the endoscope 10 in a specified orientation within the tube, e.g., equally spaced from

the inside surfaces 45 of the tube. The space 13 defines a space for irrigation fluid.

The sheath may be formed of stainless-steel or other sterilizable material. For example, sterilizable plastic may be used. The sheath also has a connector fitting 42 at an end thereof that is at the opposite end from the end where the image is acquired. As shown, the connector fitting may be an enlarged portion in which the diameter of the exterior part of the sheath becomes expanded.

A coupler 30 connects between the endoscope 10 and the extension 16. The coupler may provide a fluid-tight but rotatable connection. In the Figure 1A embodiment, the coupler includes an irrigation passage 32. A source of fluid 34 is connected to the irrigation passage which passes through the coupler, into the irrigation space 13. Coupler 30 also includes an attachment mechanism 36. The attachment mechanism may be an annular groove which snaps into place. The coupler may also have inner surfaces 31 which press against the outer surfaces of the endoscope section 10 and against the outer surface 15 of the extension 16. Once snapped into place, the coupler holds the sections 10 and 16 into optical registration with one another.

The connection between the sheath 14 and the extension 16 is rotatable, and also provides a fluid tight seal for irrigation fluids. In the embodiment, an oval ring 44 is

received within the inner surfaces of the connector. The oval ring forms a fluid tight but rotatable seal between the sheath 14 and the remainder of the unit.

The end portion of the sheath, in operation, is adapted to be located in the area desired to be viewed. A window 52 is located at the desired area of viewing. The window can be annular, for example, and can include transparent material therein, or can be totally open. The window may also direct the irrigation fluid to the mirror in order to clean the mirror and flush the region adjacent the viewing region of the endoscope.

The area of viewing is at an angle relative to the sheath 14, which is a non-zero angle, which means that the area is not directly in front of the sheath. An optical element, e.g., mirror 50, is located adjacent the window. In this embodiment, the mirror is mounted at a fixed angle, that is, the mirror forms a fixed angle relative to an axis of the sleeve assembly. In other embodiments, the mirror may be movable as explained herein.

In this embodiment, the mirror is a fixed angle mirror - that is the mirror is mounted at a specified fixed angle. A plurality of sleeves are provided; each having a different fixed angle. The different sleeves form a set of interchangeable parts. Figure 1A shows the mirror mounted to reflect 45 degrees, with 45 degrees being the first angle.

Figure 1B shows an alternative portion which may be used in the embodiment of Figure 1 and which has a different angle of reflection. In the Figure 1A embodiment, light may be reflected by 67 ½ degrees. A number of different angled pieces are maintained. These pieces may allow different orientations relative to the endoscope to be viewed. Any viewing angle can be selected as is appropriate to the surgical procedure.

In operation, the user can view different angles based on the geometry of the mirror assembly which is selected. The user can also rotate the fitting portion 42 in order to view at different angular orientations relative to the fixed angle mirror.

An orientation part 54 may include an enlargement on the exterior of the fitting portion of the sleeves, and may be provided to allow tactile feedback to the operator about the viewing orientation that has been selected.

The endoscope 10 is also coupled with a video section 20. As shown, the endoscope may be coupled through the intermediate fiber length 16 to the video system 20. Video system 20 may include an optical lens assembly as well as image processing circuitry 24. Use of the optical fiber length 16 may allow the video element to be positioned more remote from the endoscope unit. In an embodiment, the insertable portion of the endoscope 10 is presterilized and packaged as a sterilized unit. The end

of the extension 16 may be surface decontaminated and draped. The endoscope 10 may then be connected to the extension 16 for operation. The extension can be used many times, and with many different endoscope parts. Only the endoscope part needs total sterilization, e.g., not the whole of the extension 16. The endoscope part can be resterilized, or disposable.

The video section 20 receives light indicative of an image from the endoscope 10. The information is coupled to video processing circuitry 24 which may process the resultant video signal and generate information and/or display. The display may be sent to a monitor 26.

Image processing circuit 24 may also include a filter which can be a selectable filter which electronically smoothes the image. Different image processing operators are known in the art, and art described in (Rosenfeld, Kak textbook here) as well as in Texas Instrument application notes for its families of digital signal processors.

The mirror may also reverse the image to its mirror image. Hence, the image processor may also include an inversion part 62 to electronically mirror-invert the image in order to compensate for the effect of the mirror. The image processing may also include a rotation processor 64 which may rotate the display image. The rotation processor 64 is connected with an operator control element and enables the operator to rotate the image to

a selected orientation. All of the image processing operations, including those disclosed herein and others, may be carried out by a single digital signal processor (DSP) chip, e.g. one available from Texas Instruments.

A light source 28 may direct illumination light to the area being imaged, e.g., through a portion of the fiber-optic bundle, or down a separate light guide. The illumination light is used to illuminate the area whose image is received through the endoscope 10.

A text data generator 66 may generate textual information to be displayed on the monitor 26. The textual information can include status information such as the angle of the mirror, date, time, serial numbers, patient information and the like. The video system may also include a recorder 68 which can record selected images. The recorder may be connected to the monitor 26, which is capable of providing a split screen display showing different views which occur at different times, along with textual information about those views.

Figure 7 shows an alternative embodiment which uses a movable mirror. In this embodiment, the entire end portion 80 of the sheath may be optically clear, so that different areas can be imaged by moving the mirror. The mirror may be moved by a selectively-pressurized fluid, e.g., which is controlled by

application through a syringe. The control may by via an electrically driven motor 70, as shown.

The mirror is pivoted about the pivoted mounting 71 and can be moved between its angular limits defined by the interior surfaces of the sleeve. The motor 70 may be controlled by the operator as desired until the desired angle is achieved. At any time, the motor's current position is monitored by the text generator 66, and may display an alphanumeric display of the viewing angle.

Since the mirror can be pivoted in this embodiment to image at different angles relative to the endoscope axis, and also rotated by rotation of the endoscope assembly to obtain different orientations of viewing, a very large field of view may be imaged by the single endoscope insertion. The image processor may also include image stitching software which may stitch together multiple parts obtained at different orientations or angles, to provide a single composite wide field of view.

Figure 2 shows an alternative embodiment which allows viewing multiple discontinuous views simultaneously. In this embodiment, a lens 82 is located at the front portion of the sleeve. The Figure 2 embodiment may also include the same structure as otherwise shown in Figure 1. Alternatively, the

front of the sleeve can be left totally open in the Figure 2 embodiment.

In this embodiment, the mirror 84 is connected to the sleeve as previously described. The mirror may be fixed as in the Figure 1A embodiment, or may be movable as in the Figure 7 embodiment. The mirror 84 extends over a shorter distance, however, then the corresponding mirror 50 in the Figure 1A embodiment. In this embodiment, the mirror extends only to a point partway across the center diameter of the fiber 12. This couples the image only to part of the fiber. The other part of the fiber receives a different image from a different angle. This allows forming a split image on the fiber. A first part, e.g., half, of the image received by the fiber 12 is reflected by the mirror. This first part is obtained from the side of the fiber, at an angle defined by the angle of the mirror 84. The other part of the image is a straight ahead view which is oriented generally along the axis of the endoscope. Alternatively, another side looking view could be obtained, by using a second mirror.

The interface between the two images is at a preselected location, e.g. halfway across the fiber or some other specified percentage across the fiber. In an embodiment using a single mirror embodiment, the mirror imaging circuit 62 may be set to reverse only the corresponding fraction of the resulting image

which actually comes from the mirror reflection. The mirror 84 may have a marking 85 at its edge portion to facilitate subsequent image processing. This marking may be a black line, a hologram, or any other marketing that can be found in the image field by the image processor. Markings from above the line will be inverted by the image processor and may be labeled as the first image part. Markings from below the line will not be inverted, and may be labeled as the second image part.

The mirror 84 reflects the image part such that it covers only a portion of the active area of the endoscope. The remainder of the active area of the endoscope may therefore be used for another image, or for any other purpose, such as for illumination. The ratio between the areas can be set as desired.

Figure 3 shows another embodiment which has a surgical tool 90 attached to the outer sheath. This surgical tool may be, for example, a forceps or some kind of trocar assembly. This embodiment may use any of the other endoscope embodiments described throughout this application. In addition, the surgical tool is connected to the sleeve assembly, as previously described in the embodiments above.

Figure 4 shows the endoscope 110, which may be any of the endoscopes described in this application, being received in a sheath that is formed of a light transmitting material. The

sheath at 146 may be tube shaped as in other embodiments. In addition, the sheath at 146 may be formed of sterilizable clear plastic. The sheath is coated on its inside and outside surfaces with a mirror or other light reflecting coating 148. The clear material 146 located between the two mirrored surfaces 148 may form an optical waveguide between the inner surface 145 and the outer surface 147. Any optical confining media may be used in place of the materials described herein. As in the other embodiments, a window 152 allows imaging of the desired area.

In operation, the illumination source 28 is optically coupled to provide its light into the optical waveguide area 145. The light travels down the optical waveguide 145, confined between the inner and outer surfaces. The light arrives at the window 152 where there is no reflective coating. This forms a ring of illumination light directed to the region adjacent the sheath. The illumination light is directed outward as shown. Reflections from the illumination light are received as an image received through the window 152, off the mirror 151, and into the endoscope 110. As in the other embodiments, the mirror can be fixed or movable, and can be available in multiple sets of different fixed angles. The sheath at 143 may also be rotated to image different areas at different orientations.

Figure 5 shows an alternative embodiment, using a mirror sleeve assembly 240. The sleeve assembly 240 may be a shortened viewing tube relative to the other embodiments. The sleeve is received at the end of the scope section 210. The scope section 210 may include an optical fiber bundle forming a flexible light guide, leading to a video section which may be of any of the types previously described. An anchoring mechanism 242 may include a friction fit, a lip, detent arrangement, threads, bayonet fit, twist lock, or other similar sealing system. The sleeve assembly may also include an angled mirror 250 adjacent a window 252. As in the above embodiments, the mirror may be oriented at a fixed angle, with the number of different fixed angle mirrors being available as different options, or may be a movable mirror. The window may include al lens or covering shown as 254 that seals the interior of the sheath.

Figure 6 shows an alternative embodiment, usable with any of the previously-described endoscopes, but which processes the image electronically, and does not use an optical cable. In this embodiment, the endoscope section 310 include walls generally shown as 309 which end in a proximal section 311. A lens 322 is attached to the end of the proximal section, and positioned and oriented to direct incoming light to a camera chip 320. The camera chip 320 accepts the incoming light, and converts the light into an electrical signal. The electrical

signal is coupled to a cable 324 which extends through the wall section 309 and may connect to the video processing circuitry as previously described.

This system may also include a light guide shown as 330 extending through the scope to provide illumination light to the tip region. Alternatively, the end of the scope may include a light source, driven by electrical power sent on the cable 324 or on some other cable.

The light is preferably provided at the same angle as the imaging by the camera. The light is bounced off the mirror 350 to illuminate the area of interest. The reflections of that light also bounce off the mirror, and are received by the camera.

The lens in this, and in any of the embodiment, may be replaced by any optical element, including plain glass or a hologram, depending on the optical configuration.

This embodiment may be used with any of the previously described embodiments. For example, this embodiment may use fixed mirrors as in Figures 1A-1B, or a movable mirror as in Figure 7. This may also use a partial mirror as in Figure 2, which obtains two separate images. One of the images is coupled to a portion of the camera by the mirror 84, with the other portion of the image going to the remainder of the pixels of the camera.

This system may use any of the sleeves as previously described, and may also use the movable mirror, and also the alternative mirror configurations.

In operation, a trocar may be sheathed in a cannula and inserted through the patients skin in a region of interest. Then, the trocar is withdrawn, leading only the cannula in place as a guide. The endoscope in any of the previously-described embodiments, along with its sleeve, are then inserted as a unit through the cannula. The light source and irrigation may be started. The irrigation, if used, may provide sterile saline solution or other fluid into the area of interest. The fluid can flush debris and also clean the mirror and the area to be seen.

The angles of viewing, including the orientation angle, and the mirror angle, can then be set. The operator may rotate the mirror relative to its sleeve assembly to obtain a better view of the region of interest. In the fixed mirror embodiment, the user may remove the terminal end of the endoscope element and insert another endoscope. In one embodiment, the endoscope can be removed from the sleeve, and inserted into another sleeve with a mirror at a different fixed angle.

Although only a few embodiments have been disclosed in detail above, other modifications are possible. For example, although the above has described a separable mirror

sleeve/endoscope assembly, the elements could be packaged as a single piece. Other materials besides those described herein could be used. In fact, the sheath could be made of virtually any sterilizable material. Different kinds of optical waveguides, besides the described optical fiber, can also be used.

In addition, the above has described the movable part which changes the viewing angle of the endoscope as being a mirror. Other movable components besides the mirror could be used. For example, an optical assembly such as a lens could be used which has viewing characteristics which change light position, or which change position relative to another lens. Hence, the movable component could be a movable lens assembly. In addition, holographic elements could be used, or a diffractive optical element. By moving the holographic element, a different optical characteristic is obtained. Other movable mechanisms are also contemplated.

In addition, while the above describes the signal processing being carried out using either a processor or digital signal processor, other processing techniques are also contemplated. For example, a second mirror could be used to invert the image, in place of a video processor being used for the image inversion. This second mirror can also act as a relay, which may allow different angles of light to be imaged.

The above describes a mirror being used to change the direction of light. However, other optical elements could be used for this purpose, including lenses, holographic element, diffractive optical elements or others.

All such modifications are intended to be encompassed within the following claims: